Activities in Support of v5 at NOAA/NESDIS

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NOAA/NESDIS/STAR

Sep. 26, 2006, AIRS Science Team Meeting

Murty Divakarla: Operational sonde databases (T(p), q(p) & O_3(p))	Thu. 9:10
Antonia Gambacorta: NSA,SGP,TWP ARM Validation, UTH	Wed. 2:30
Xingpin Liu: Re-processing, Statistics, Trace gas web-page	-
Eric Maddy: CO_2 retrieval, tuning, Averaging Kernel.	Thu. 8:50
Nick Nalli: AMMA cruise	Thu. 3:30
Fengying Sun: New RTA Installation, Convective Products	Wed. 1:50
Haibing Sun: MODIS & AIRS Co-locations	Fri. 10:40
Jennifer Wei: O_3 retrieval, START/WAVES/AMMA experiments	Thu. 11:40
Walter Wolf: Near Real Time Processing & Gridding System	-
Xiaozhen Xiong: CH_4 retrieval	Thu. 1:30
Lihang Zhou: Regression Retrieval & Near Real Time Web Page	Wed. 2:10

Topics

- Quick Summary of NOAA Test-beds & Diagnostic Tools
- Contributions to version 5.
- Assessment of version 5.
- What we plan to do for version 6.

Provide Real Time Products to NWP, Military, and Science Users

- July 2005: Began to provide NWP centers the warmest FOV BUFR product. This is in addition to center FOV products.
  - 99% of all AIRS data distributed within 3 hours to 13 NWP centers
  - Sporatic downtime due to downlink, system failures, etc. < 1 week in a year.
  - 83% of all AIRS is distributed within 2 hours.
- July 2005: v4.0.9 Level-2 running in near real time.
- Nov./Dec. 2005: Provided real time radiances and products to START experiment. → Laura Pan's talk Thur. 9:30
- Feb.-May 2006: Provide INTEX-B/MILAGRO real time radiances and products to Wallace McMillan → Thur. 11:20
- June-July 2006: AMMA/AEROSE-II → Nick Nalli Thu. 3:30
- July-Aug 2006: Provide WAVES real time radiances and products to Everett Joseph & Dave Whiteman → Fri. 11:10
- Aug. 2006: Began providing all FOV's, 281 chl BUFR to NCEP
- Aug. 2006: Providing L2 products to NRL/NCAR-RAP
- Sep. 2006: Provided UMCP 2 months of gridded "v5" products for assimilation experiments → Li/Kalnay Wed 8:50
- Plus many other in-situ experiments: AVE, EQUATE, …
- L1 & L2 Products to CIMSS, JPL,NRL, …, NOAA

Validation and Inter-comparison Using SONDE databases.

- Collecting all operational sondes within ± 100 km and ± 6 hours of AIRS observations from all RAOB sites, worldwide.
  - Roughly 150 sondes per day.
  - Launch times and location of RAOB sites result in large numbers of sondes along US west coast and European west Coast.
- We limit sondes used in our analysis
  - ± 3 hours
  - ± 100 km
  - Trusted sonde types and locations
- From Sep. 2002 to Mar. 2006 there are about 163,000 sondes (≈ 5 GB/year) of which 138,312 (85%) pass the time and distance criteria and 120712 (74%) pass all criteria.
  - 33408 over land
  - 12284 over ocean
  - 900 are clear (via George's clear flag)
- Supplementing this database with ozone-sondes → Murty's talk Thu. 9:10

Divakarla et al. 2006 JGR doi:10.1029/2005JD006116

Re-processing capability using AIRS Golf-ball Subsets

- This activity utilizes the near real time AIRS processing system developed by Mitch Goldberg, Walter Wolf, and Lihang Zhou
- The complete AIRS golf-ball closest to the mid-point of a fixed 3^o x 3^o uniform grid is extracted and saved
  - 120 longitude by 61 latitude cells
  - Separate file for ascending and descending orbits
  - AIRS, AMSU, and HSB L1b
  - ECMWF, and GFS forecast files
  - MODIS L1b on AIRS FOV's available since 11/04 (clear & cloudy)
    - However, simple spatial footprint was used. Correction in work.
- ≈2x6500 =13,000 golf-balls saved per day since Aug. 2003
  - 13,000/324,000 = 1:25 of full-resolution data.
- Reprocessing Advantage
  - 3+ years (≈ 1 TB/year) can be re-processed in a few days (on 8 generic cpu's)
  - Small systems (5 TB) can hold entire AIRS dataset
    - L1b radiances, ECMWF, AVN, and multiple sets of retrieval products.

Ability to Perform Diagnostics on Full Retrieval System

- Monitoring of radiances and products.
  - Web-based visualization to find problems.
- Science version of retrieval system.
  - Fully backward compatible to earlier versions.
  - Operates on all datasets
    - HDF granules
    - Validation files (NSA, SGP, TWP) → Antonia Gambacorta Wed. 2:30
    - UMBC RTP files (single FOV's)
    - NOAA 3x3 gridded datasets
    - NOAA operational sonde network.
  - Radiance and product statistical and case-by-case visualization tools
- NOAA Goal → Ability to utilize validation datasets to verify and improve retrieval performance and product utilization by our customers.

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Support PGE Focus Groups: Tuning &Trace Gas

- New RTA "wrapper" delivered to GSFC in Dec. 2005 for incorporation into PGE.
  - Modification to regression to splice UARS above 1.5 mb
- We accomplished closure on tuning with respect to overpass-coordinated sondes.
  - Mixed use of retrieval and overpass-coordinated sonde products to compute a tuning in which LW & SW agree and radiance tuning is minimized
  - Multiple iterations between NOAA & UMBC to minimize radiance tuning..
- Used gridded 3x3 datasets to provide IR retrievals for 160,000 clear scenes for microwave tuning
  - delivered to MIT in late Dec. 2005.
  - New tuning derived by MIT in Jan. 2006
- Averaging kernel *estimate* methodology delivered to UMBC & GSFC for installation into PGE. → Eric Maddy's talk Thur. 8:30
  - Useful for validation and use of trace gas products.
  - Ability to characterize full system (regression and physical products) via "brute force" perturbations.

Development of Trace Gas Products.

- Working with Wallace McMillan to install CO retrieval into version 5.
  - MOPITT CO first guess
  - Namelist and code to GSFC (for installation into PGE)
- Development of Averaging Kernel Functions for PGE product.
- Development, validation, and re-processing of AIRS methane and carbon dioxide product.
  - See talk by Xiaozhen Xiong on Thur. 1:30.
  - Working with a number of modelers to evaluate product utility.
- A number of CO_2 climatologies explored:
  - Simple CO_2 climatology installed for v5.0 at JPL.
- SO_2 near real-time flag implemented Jan. 2006.
  - L1 is now provided to Fred Prada to produce SO2 retrievals.
- Exploration of HNO3, N2O, and SO2 retrievals.
  - Tracking what Scott is doing for HNO3 & SO2 → Scott Hannon Thur 11:00
  - Working with Arlin Krueger & Simon Carn.
  - Exploring our own methodology to provide averaging kernels.

Led Emissivity Focus Group

- Upgrade of emissivity regression training
  → Lihang Zhou's talk Wed. 2:10
- Explored many options to initialize and retrieve emissivity
  - Using MODIS database
  - Using Bob Knutesons on/off line approach
  - Various fitting methods and spectral functions.
- Worked with Evan Fishbein to improve cloud clearing channel selection over land.
- Provided Bob Knuteson our emissivity retrievals (v5 emulation) from clear scenes in the 3x3 grid runs. → Bob Knuteson's talk on Thu at 4:20

Developed and Installed the AIRS-Only Regression

- Mitch introduced idea in early 2004
  - Partly due to recognition that principal component scores associated with cloud eigen-vectors tend to be ignored in cloud-cleared regression training.
- Lihang derived initial set of coefficients in 2004. We presented results at a number of science team meetings and SPIE in San Diego.
  - Mar 30, 2004 STM: Showed CLDY REG had less bias than MIT, higher yield.
  - Feb. 17, 2005 Net Mtg
    - Removed AMSU Adjustment to regression (this should have been removed after loss of HSB).
    - Used v4 physical QA for rejection: higher yield, less bias & RMS than v4 system
    - Detail analysis in frontal zone – system does not "stick" to first guess
  - May 5, 2005 STM: Showed v4-like QA could be used (w/o microwave) to provide better results than v4, but with slightly less yield at lower levels.
  - Aug. 3, 2005 SPIE 5890: summary of ASTM talks
- July 2005: Lihang installed code modifications into PGE via Evan Manning.
- Explored additional QA using George's PLR test
- Explored using AMSU brightness temperatures as predictors (for system with AMSU).

A number of other PGE Improvements are based on our analysis & recommendations

- Removal of ad-hoc model error term.
- Recommended to NOT accepted cases that converged on "75% test"
  - In PGE we force at least 3 iterations before this test is done.
  - We still accept about cases that do not converge (≤ 1%).
- (Sep. 2005) Recommended that we use information content and residual's in rejection criteria – we added this to NOAA QA of trace gas products.
- Explored new physical error co-variance terms
  - CO_2 in T(p) and cloud clearing (<u>installed in PGE</u>)
  - CH_4 in q(p): negligible impact
    - NOT NEEDED unless we want to use CH_4 channels in q(p) retrieval
  - HNO_3 in surface, CH_4, and q(p)
    - not needed if we avoid HNO_3 channels in q(p) and surface retrieval
  - P_{surf} error in T(p) and q(p) retrievals: TBD (v6?)
- Ozone Retrieval Optimization
  - More tropospheric functions, modifications to damping in PGE
  - Attempt at new training using TES -- too sparse
  - Building an ozone-sonde database → Murty Divakarla's talk, Thur 9:10

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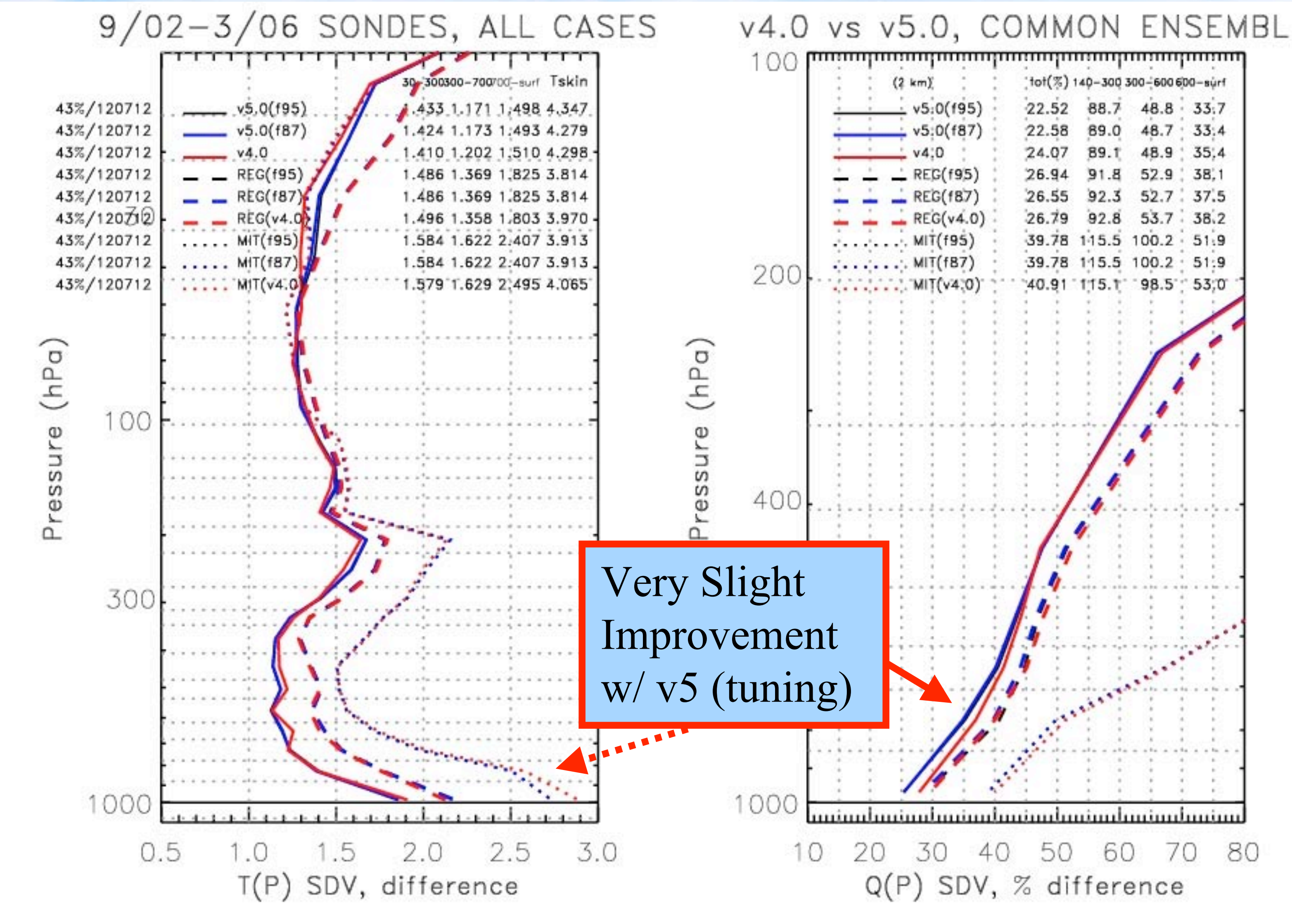
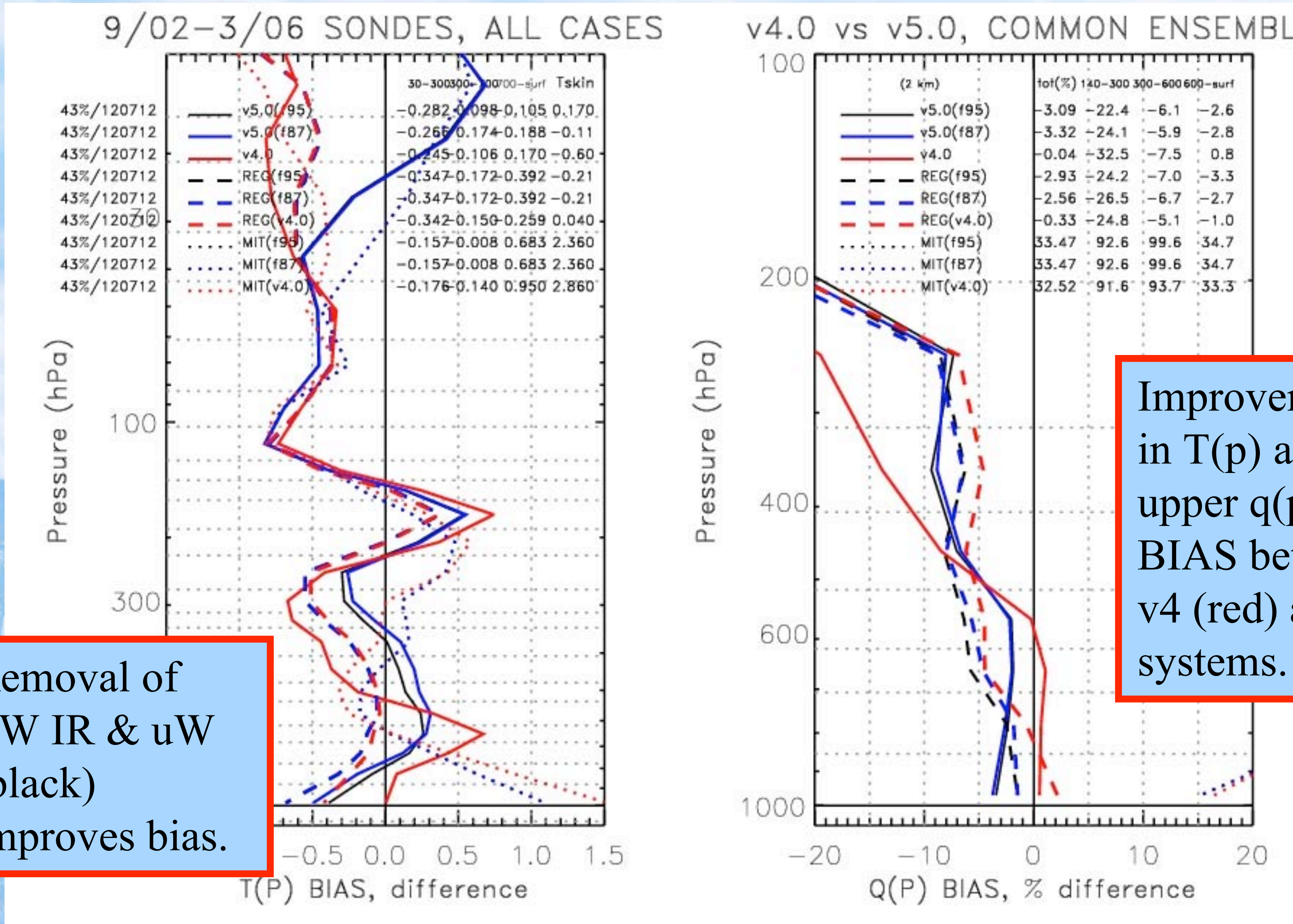
Preliminary Comparison of v4 and v5 systems versus operational sondes

- Use a “qual_temp_mid=0” test for all runs. Entire profile accepted if this QA test passed.
  - For users we reject lower components of T(p) and surface that are affected by clouds due to lack of information content in AMSU, etc.
  - Here I want to look at performance in this region.
- All statistics are on a common ensemble
  - The ensemble is a subset of cases accepted by all systems.
  - Illustrates improvements in algorithm, NOT QA.
- Only sondes with ± 3 hours and ± 100 km are used.
- Only used the “best” sonde types (RS-80, etc.)
- V3.18, v4.0.9, and 2 versions of v5.0 are shown
  - f87 is a v5 system with 4 emissivity retrieval and use of microwave and use of 712-755 cm^{-1} IR in coupled T(p) retrieval.
  - f95 has 1 SW emissivity, NO microwave or 712-755 cm^{-1} in coupled T(p) retrieval

v4 & v5 systems vs. sondes: SDV
MIT (dotted), REG (dash), PHYS (solid)



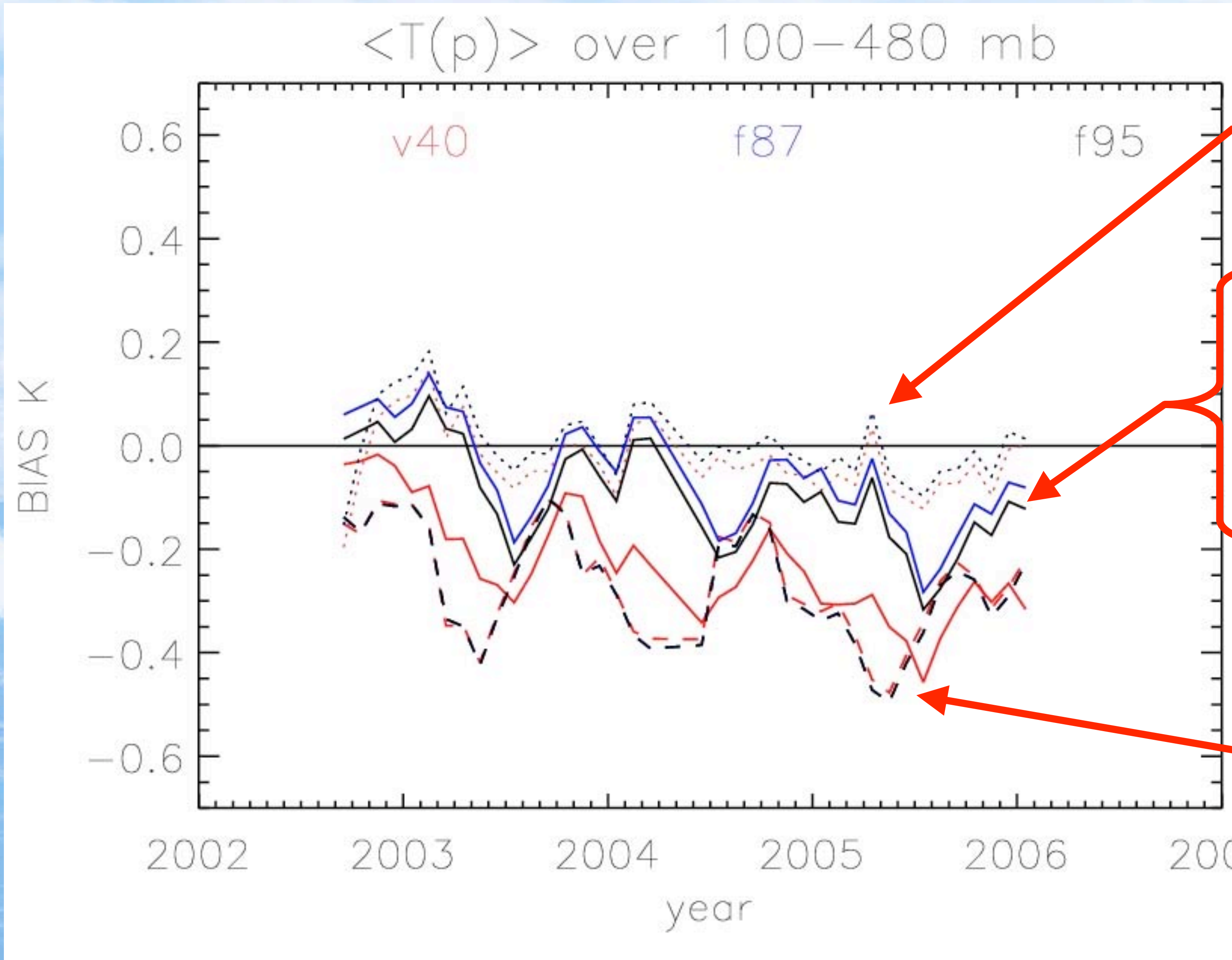
v4 & v5 systems vs. sondes: BIAS MIT (dotted), REG (dash), PHYS (solid)



Removal of LW IR & uW (black) improves bias.

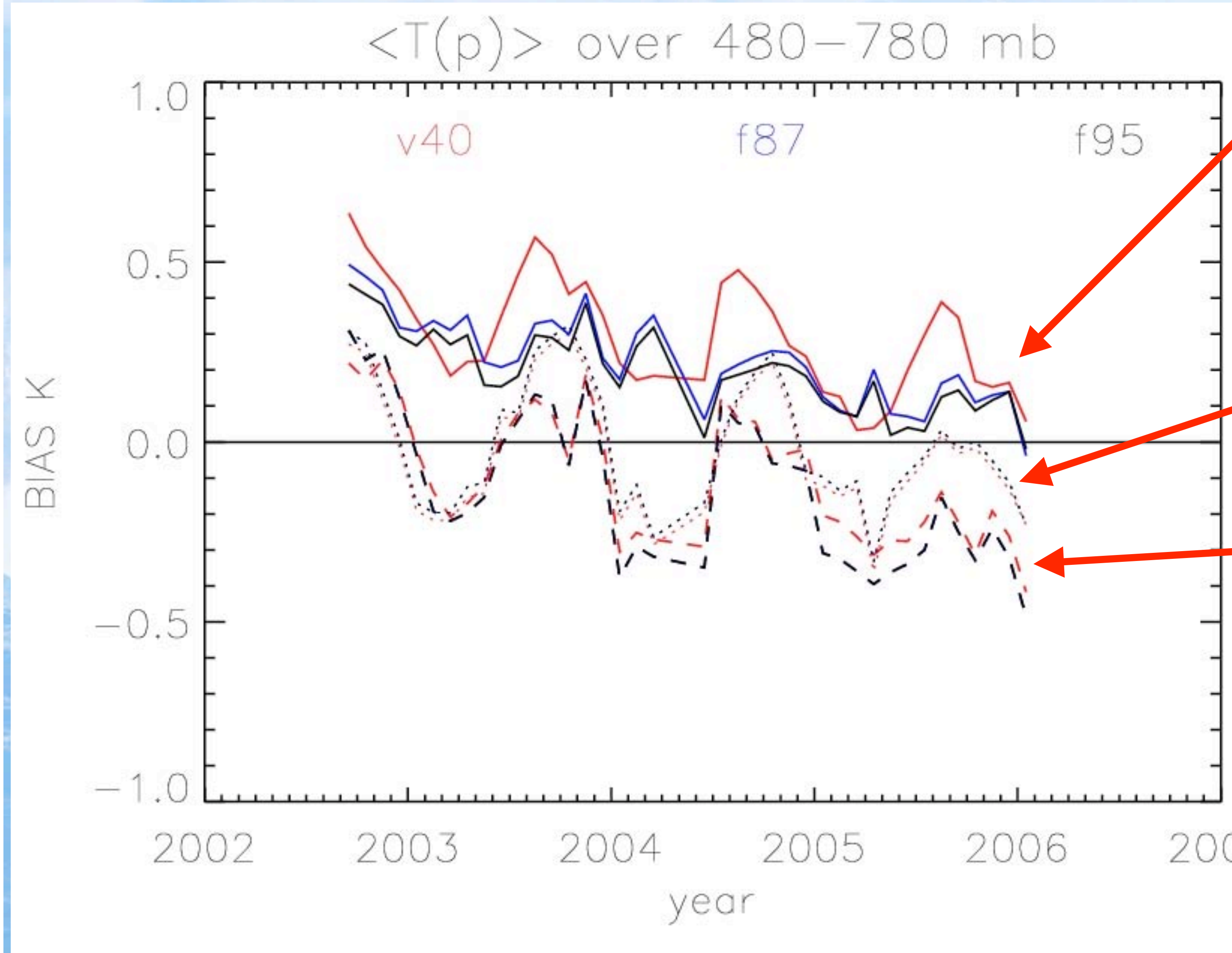
Improvement in T(p) and upper q(p) BIAS between v4 (red) and v5 systems.

100-500 mb BIAS vs. time
MIT (dotted), REG (dash), PHYS (solid)



- MIT has very small BIAS
- PHYS is less biased in v5 than in v4.
- Use of 712-755 cm-1 improves BIAS
- REG has seasonal and trend.

500-800 mb BIAS vs time
MIT (dotted), REG (dash), PHYS (solid)

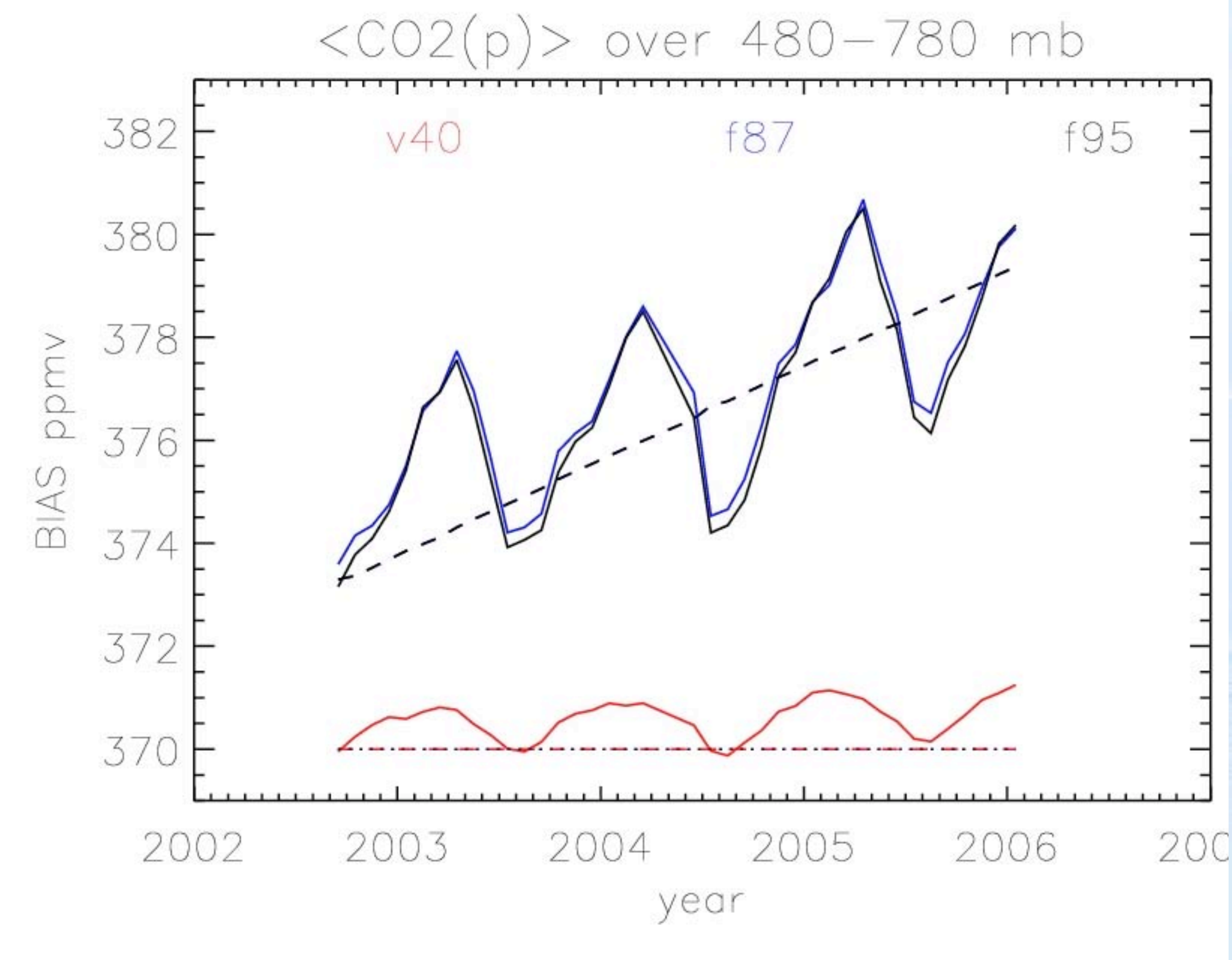


PHYS: Bias is less in v5 systems but MIT/REG biases still leaking through

MIT has seasonal and trend in BIAS

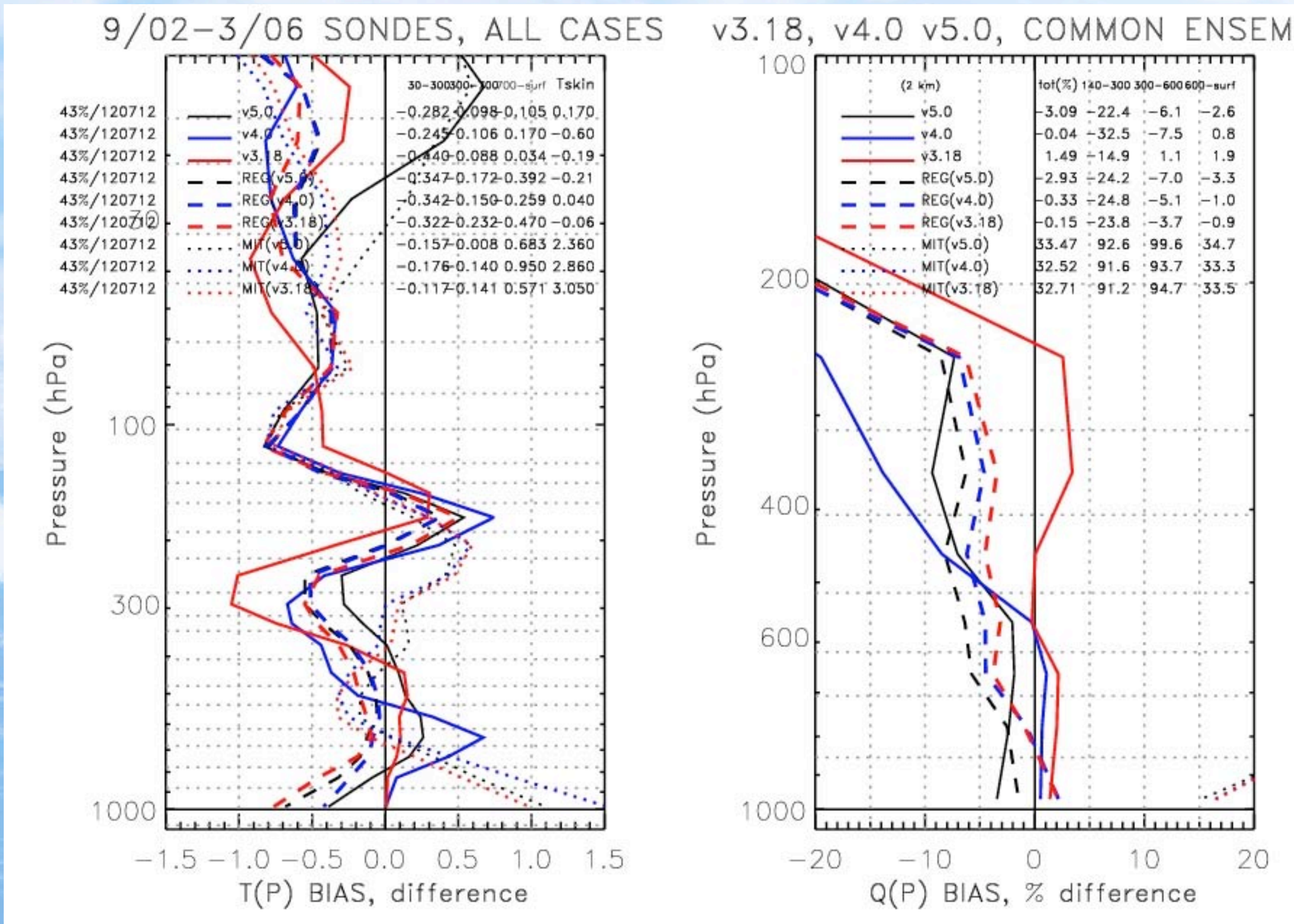
REG follows MIT bias (i.e., it leaks through cloud clearing)

CO2 fg (dashed) and retrieval (solid)

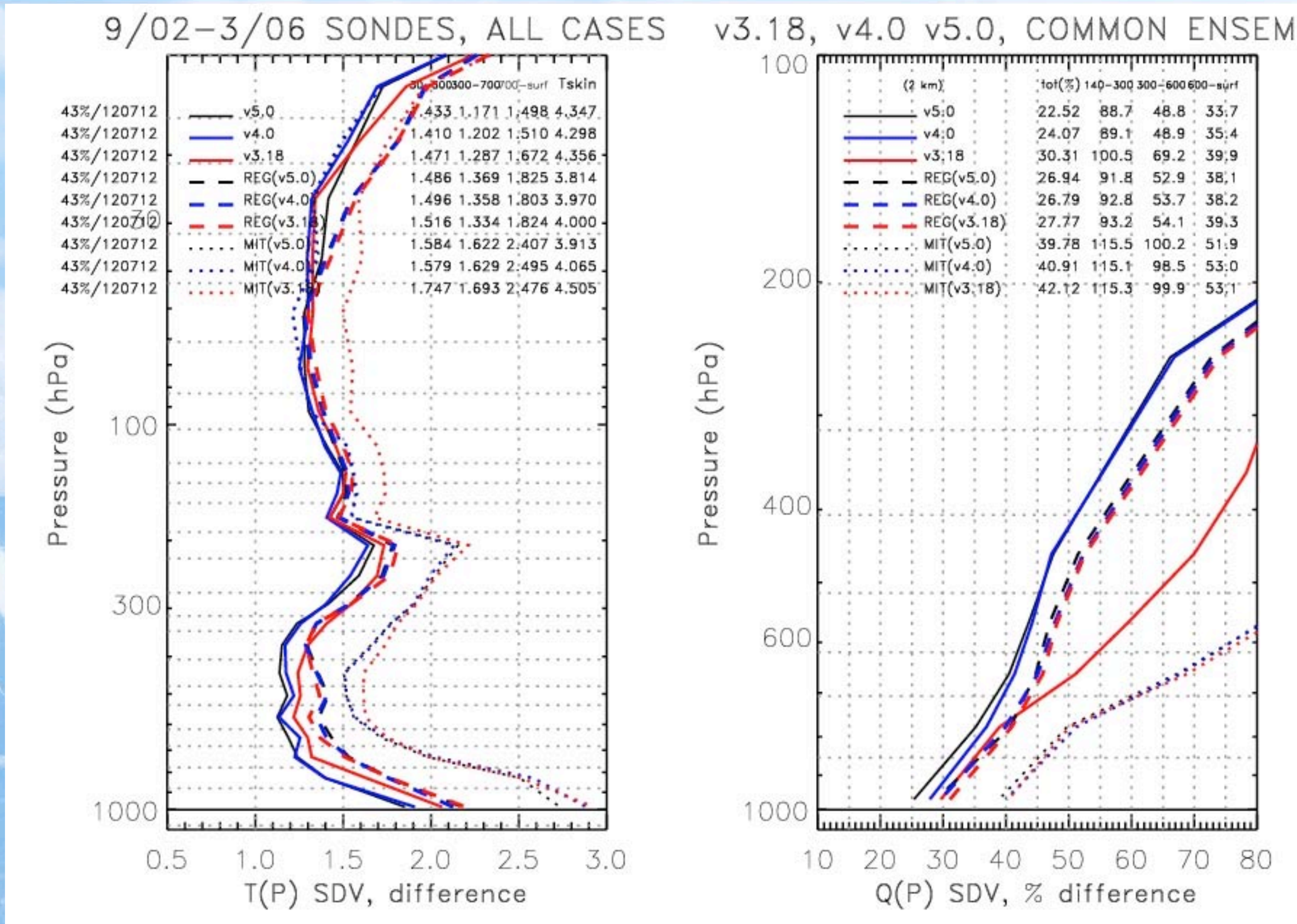


- CO2 first guess eliminates some of the trend in T(p)
- In v5 we improved the CO2 retrieval (not installed in PGE)

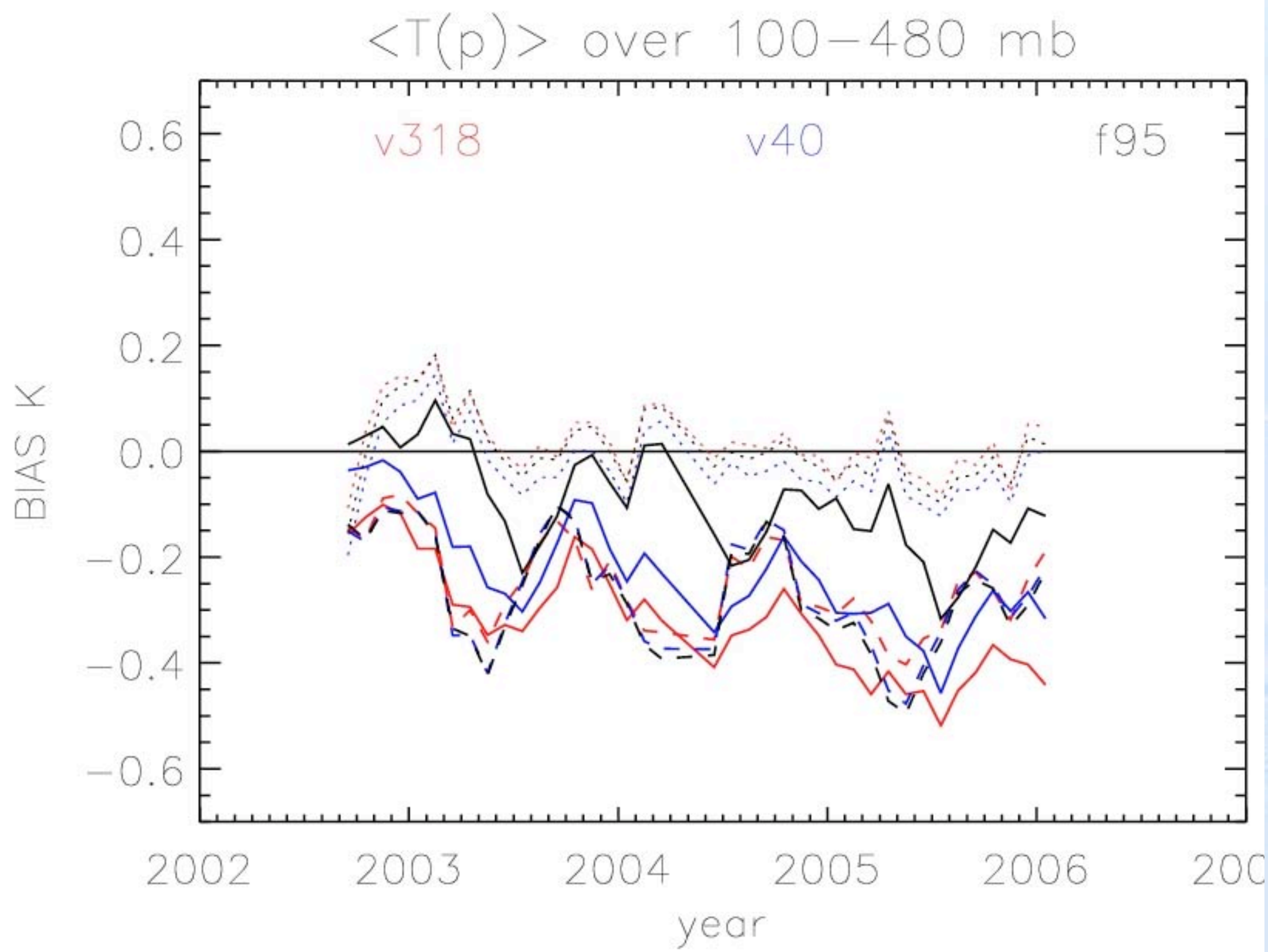
V3.18 (RED), V4.0.9 (BLUE) & V5.0 (BLACK)
MIT (dotted), REG (dash), PHYS (solid)



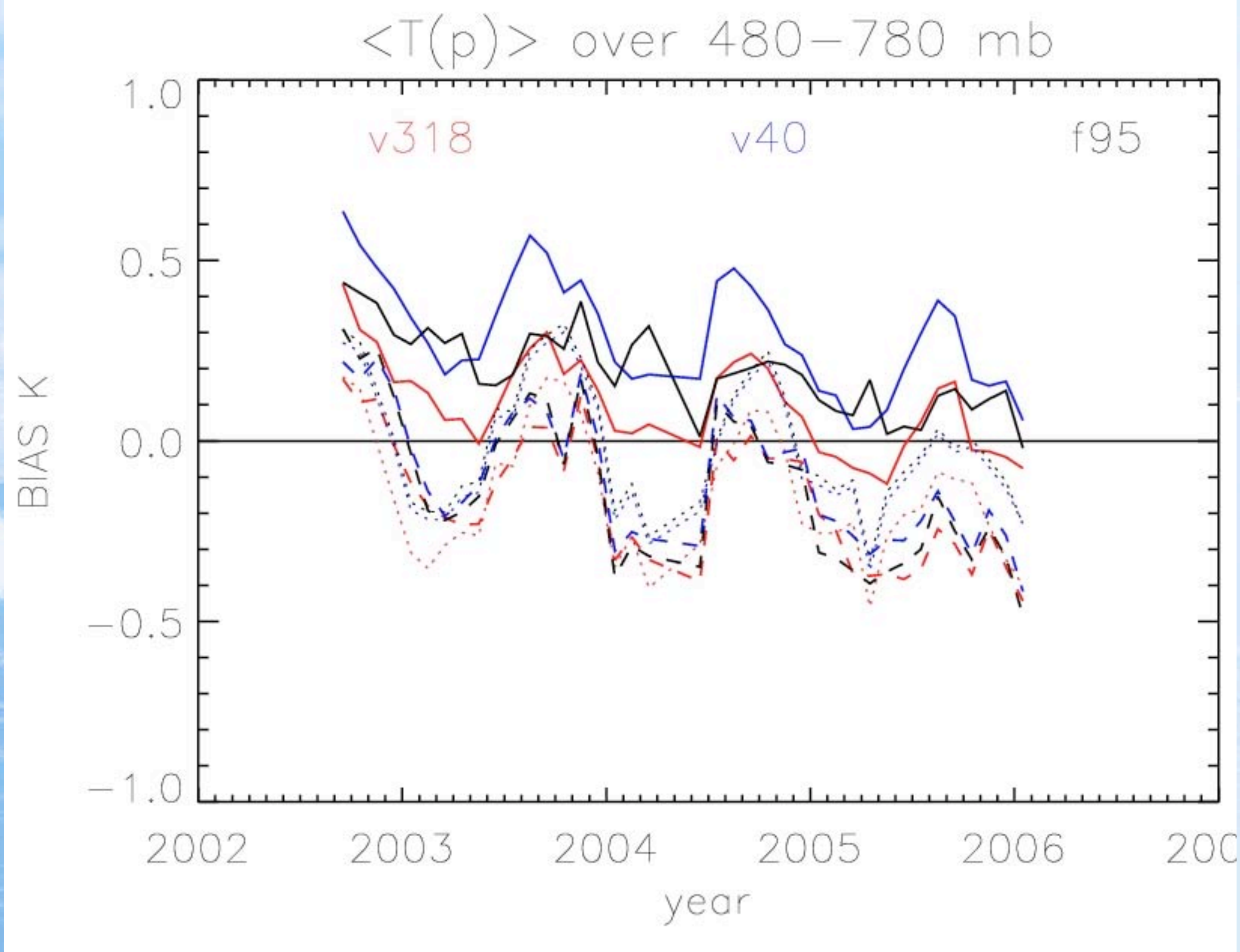
V3.18 (RED), V4.0.9 (BLUE) & V5.0 (BLACK) MIT (dotted), REG (dash), PHYS (solid)



Steady Improvement in bias from v3 through v5 in upper trop

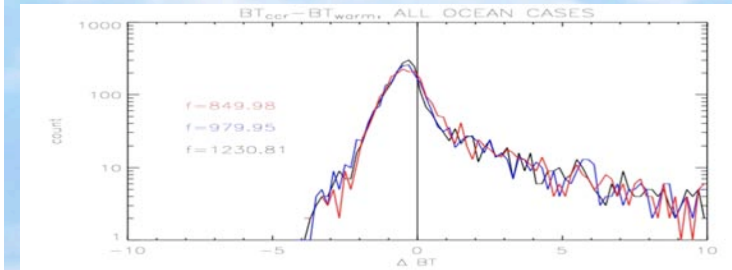


Lower trop BIAS improved from v4 to v5 & less seasonal sensitivity

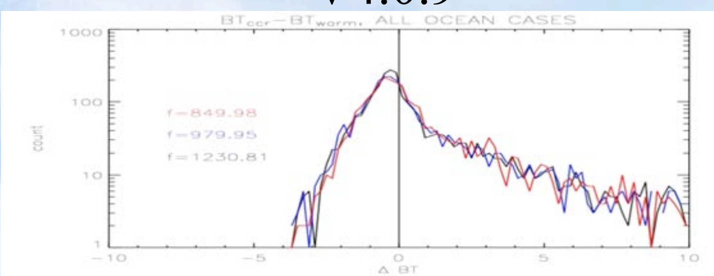


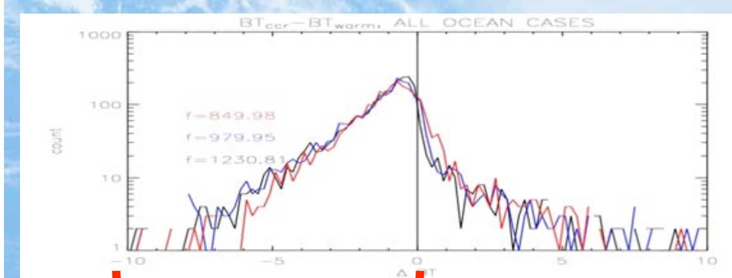
Rccr-Rwarm Ocean Cases, lat ≤ 60 (First Noticed by SY Lee)

G401, 9/6/02, v5



V4.0.9





Rejected by Surface Tests

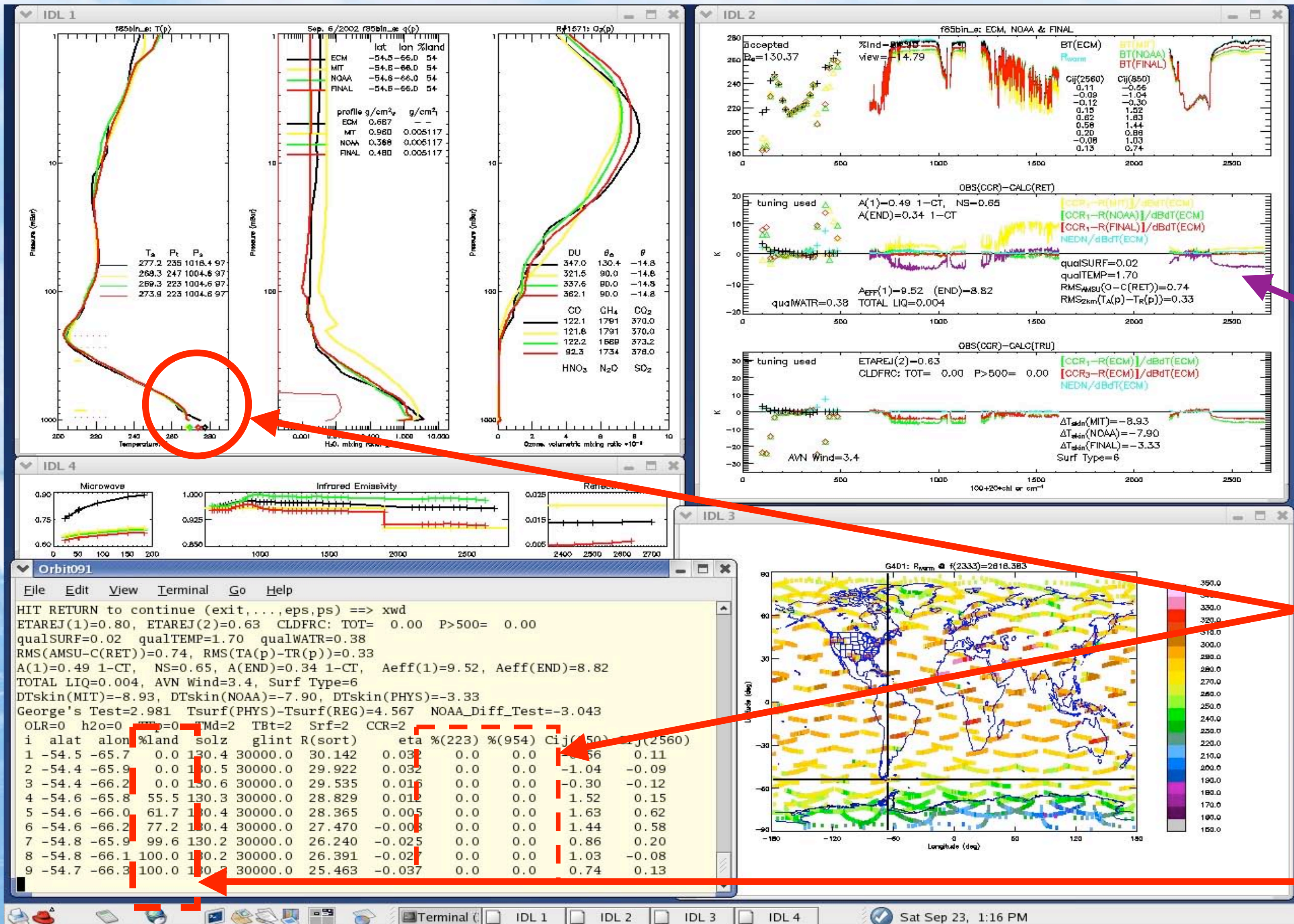
- Rccr-Rwarm should be positive for most cases (except strong inversions) due to clouds in the warmest FOV
- Note that technically in v4/v5, a radiance can only be compared if all QA is valid (qual_surf, qual_temp's, etc.). This only happens on a small fraction of the globe.
- All versions (v4,v5,etc) have this problem

$$R^{cc} = \overline{R} + \sum_i \eta_i(\overline{R} - R^i)$$

- A system that pivots off of the warmest FOV is even worse..

$$R^{cc} = R^w + \sum_{i \neq w} \eta_i(R^w - R^i)$$

Example of a cold CCR bias: Failed CC assumptions, qual_temp_bot ≠ 0

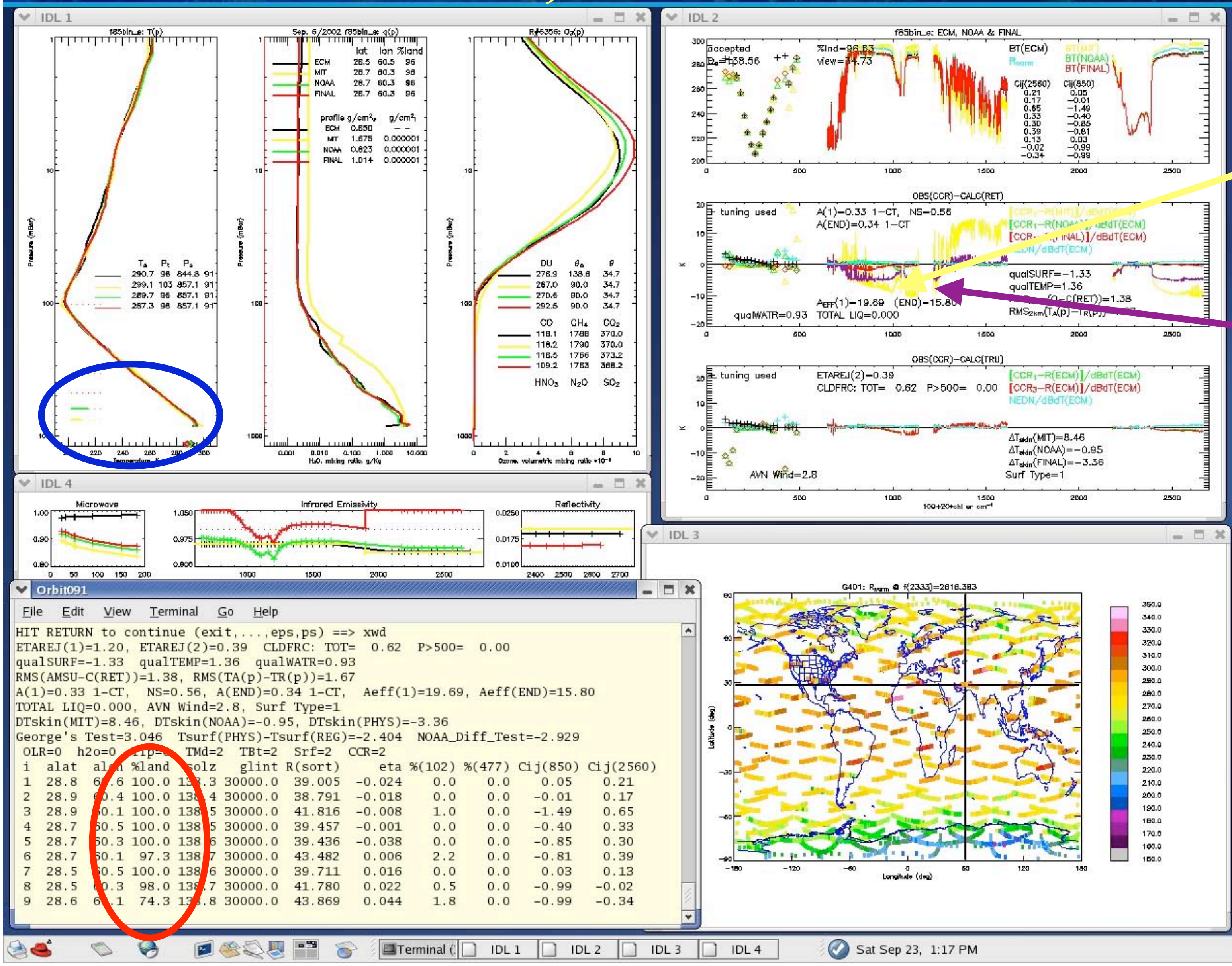


Rccr-Rwarm is really cold

Failed to detect low clouds

coastline

Another Example: MIT Starts Out OK, CCR misses clouds



MIT Starts out Warm

4 K cold bias in window region

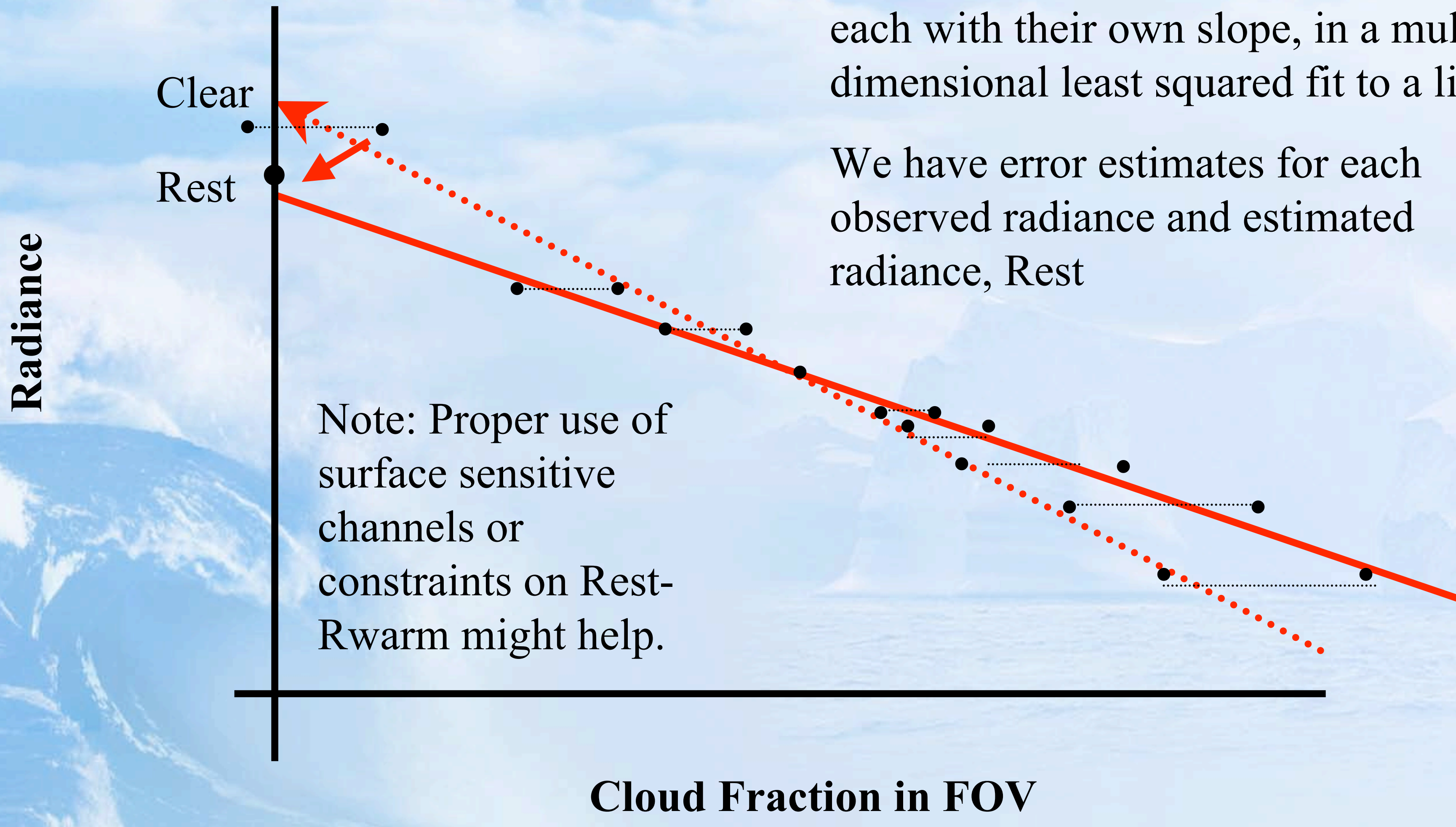
Initially we thought we had clouds, but later we zeroed them out.

Mixed land & water in scene

Cloud clearing uses observations to fit a line to the estimate of clear radiance

In reality, we use multiple channels, each with their own slope, in a multi-dimensional least squared fit to a line.

We have error estimates for each observed radiance and estimated radiance, Rest



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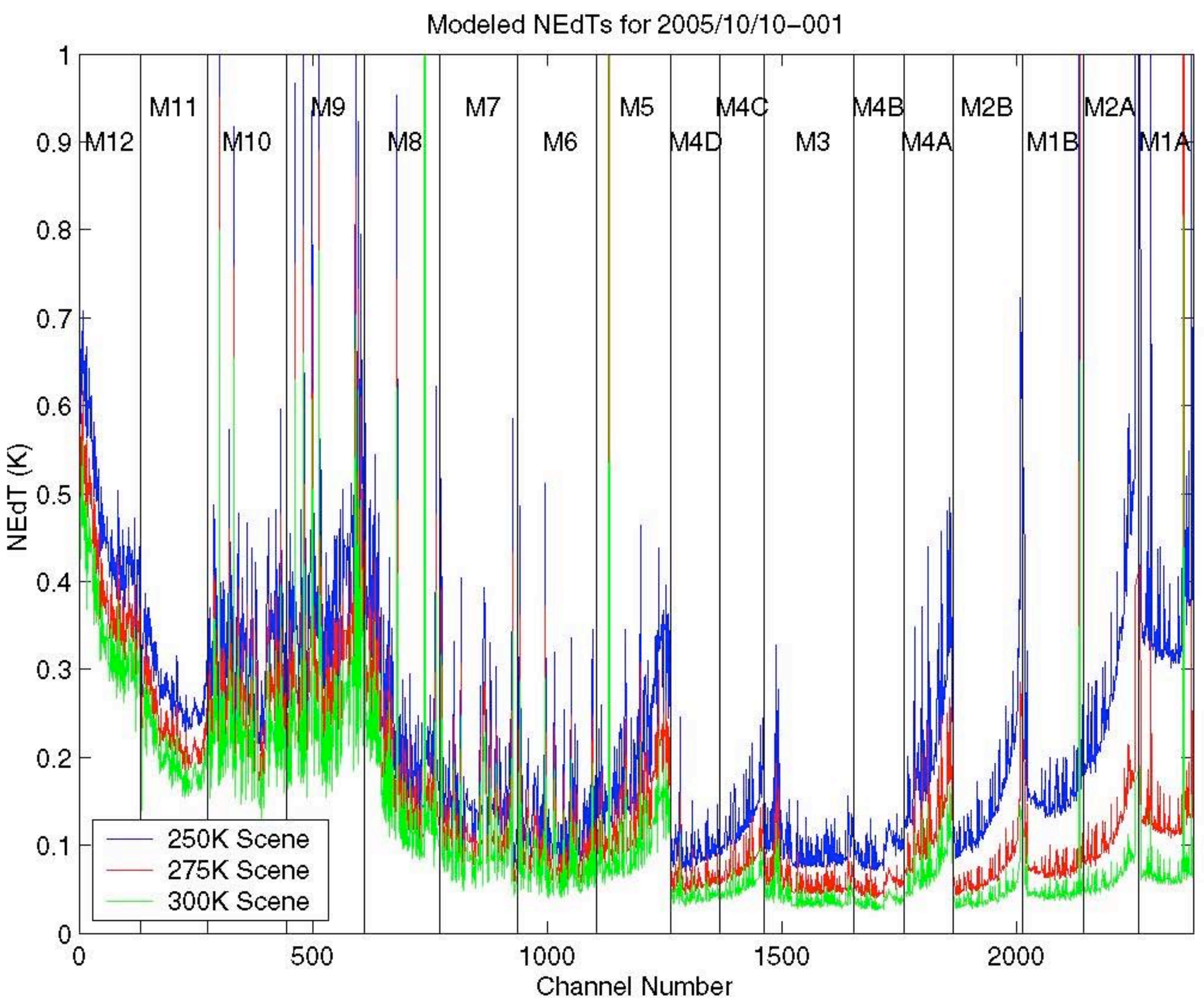
My Personal Concerns with v5

- Heavy weighting of SW chl's needs to be validated
  - We still don't have scene dependent noise. Why???
  - The non-lte correction is simple and is not a function of the observations
    - Delta.R = f(solzang, secang, <T(p=.016-.137)>)
    - <T(p=.016-.137)> comes from UARS climatology since AMSU and AIRS is not sensitive to this region.
- Optimization of algorithm is still relative to ECMWF and not validation datasets
  - We are checking algorithm changes w.r.t. sondes – so far OK
  - Water appears to be over-damped → Antonia Gamborta Wed. 2:30
  - Ozone appears to be over-damped → Jennifer Wei Thu. 11:40
- We are masking many problems with an overly complicated QA.
  - We need to improve the ability to sound in difficult cases, not reject them.
  - Cloud and surface errors can propagate vertically (e.g. see BIAS curves w.r.t sondes).
  - Radiances can only be computed from a complete state, therefore,

Calculated shortwave NEdT vs Scene temp (Steve Gaiser, 10/19/2005)



Where we are heading for v6

- We will continue to "close the loop" between validation experiments and algorithm development.
- We need to understand and remove biases in microwave and infrared products.
- Explore the use of an AIRS derived emissivity climatology.
- We need to eliminate cold biases in cloud clearing.
  - Understand situations where this arises.
  - Develop, implement, and validate solutions.
- Enhance cloudy regression & explore new QA indicators.
- Implementation of CO_2, HNO_3, N_2O, and SO_2 products.
- Explore the utility of AIRS convective products. → Fengying Sun, Wed. 1:50
- Merging of MODIS & AIRS radiances → Haibing Sun Fri 10:40
  - MODIS-AIRS co-location nearing completion
  - Use of MODIS for QA
  - Use of MODIS in AIRS cloud clearing